IDENTIFICATION AND MAPPING OF DEGRADED LANDS USING REMOTE SENSING AND THEIR MITIGATION REGIMES: A CASE STUDY OF WEST HARYANA (INDIA)

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ABSTRACT: The degraded lands require a strategic management after the threats indicated to our livelihood and food security cited by various literatures. The agricultural efficiency is antagonistically influenced by degradation of various types. This study culminates different management practices applicable to different degradation types for establishing a proper channel of supervision with reference to West Haryana. An area of 181630.36 hectares was found degraded in the study area with different categories of degradation (waterlogged, water erosion, eolian erosion, salinization and anthropogenic) for the year 2015-16. Resourcesat 2 LISS III imagery was employed to identify and map problematic lands indicating eolian erosion as the most prominent category of degradation. The categories were identified and mapped analogous to their spectral reflectance and visual interpretation. The partially stabilized dunes availed the highest place in extent of area dispersal occupying 98143.16 ha while the anthropogenic degradation (mining and brick kilns) extend to 382 ha. The influence of these categories of degradation on environment and their managing strategy has been focused in this paper. The farmer's choice of agriculture practice is an aggregate of various influential factors such as knowledge, labour, crop choice, fertilizers availability, irrigation, soil health and much more. The evaluation of problematic soils with poor soil health is the concern of present study additive of the management strategies to be adopted. Establishment of horizontal linkages between agro-forestry interventions, watershed development, integrated farming systems and degraded lands for management regimes has been brought up to enhance productivity for sustaining future perspectives. The designed approach is to reduce and reverse degradation by various practical interventions in different degradation types. The effect of degraded lands can be mitigated by stipulated action of suggested management policies reviewed in the study.

1. INTRODUCTION

The natural resource land has been on the verge of degradation since decades in an alarming need to restore and reclaim. The status of degradation in India among the world falls under the category of moderate to strong degradation (Nachtergaele and Ricardo, 2013) with its lower capacity to provide ecological goods and services (GLADIS). The northern states among the physiographic divisions of India have maximum area under degradation with account for 40% of total geographic area (NBSS & LUP, 2005). The agrarian economy of India would be more affected by deteriorating quality of land raising an alarming issue among the land users and a challenge to achieve the goals of sustainable development and to ensure food security. The negative consequences arose from reduced performance of land leads to ecological (ecosystem function collapse and loss of ecological services) and economic (reduced land productivity and of ecosystem service values) cost. The kick-off given by UN General Assembly, 2015 to reverse degradation with formal adoption to Sustainable Development Goals; the diagnosis of land degradation at local, regional and global level has been carried out. The various timely reforms in the agriculture sector are aimed at alleviating poverty and improving quality of life in rural sector. The associated changes in the farming practices with the motive to enhance productivity are coupled with degradation of the land resource. The emergent pressure on land with outgrowing population has resulted in decline of productivity. The two aspects to enhanced income derived from agriculture are to either arrest degradation or to explore and add additional areas (marginal rainfed areas or wastelands) with viability to generate produce. The intrinsic relationship shared between environment and population is of utmost importance. The sustenance of population is dependent on the environment in which it thrives. A reduction in goods and services due to degradation (Nyonya *et al.*, 2011) is observed in terrestrial ecosystem which leads to socio-economic consequences and food insecurity. The identified causes of land degradation (erosion, nutrient depletion, chemical deterioration, desertification, deforestation etc.) make soil unfit for cultivation leading to productivity decline (Turner, 2016). The strategic framework of UNCCD 2018-2030 aims at achieving sustainable development goals striving for land degradation neutrality through the process of combating desertification and restoring degraded lands. Various methodologies and approaches have been developed to assess the land degradation process viz., expert's opinion, land user's opinion, modelling, field observations, productivity change estimation and remote sensing and GIS. However, the succinct view provided by remote sensing has been a brilliant achievement of space technology and its accuracy assessment has made it more reliable technique to accurately update the database for soil inventory which could further be applicable to adoption of management strategies highlighted in the study.

The objective of the study is to analyze the distribution of degraded lands in West Haryana and suggest measures for optimal utilization of problematic areas.

2. DATABASE PREPARATION

IRS- 1B, LISS III data for three seasons: rabi, kharif and zaid for the year 2015-16 was used prior to image registration. The datasets were subjected to pre-processing and various image enhancement techniques were applied. The area of interest was extracted after processing the image for haze reduction, cloud cover removal and histogram equalization.

3. DISTRIBUTIONAL PATTERN OF DEGRADED LANDS

The western part of Haryana comprising of four districts; Sirsa, Fatehabad, Hisar and Bhiwani occupies an area of 1627.79 sq. km. of degraded lands out of 15113.57 sq. km. total reporting area. The degraded lands constitute 11% area of the western part comprising of soil erosion (sheet erosion, partially stabilized dunes and stabilized dunes), water erosion, waterlogging (seasonal and permanent), barren rocky, anthropogenic (mining and brick kilns). Highest area of degradation was occupied by partially stabilized dunes to a total of 98143.16 ha while the combined anthropogenic category of degradation (mining and brick kilns) occupied a area of 382 ha which though low in extent of area poses more severity in degradation and requires proper channel of management. Block-wise distribution of degraded lands shown in Fig.1 indicates considerable variation in proportion of degraded lands to total area of block ranging between 0 to 36 %. Significantly highest percentage of degraded lands i.e., >36% is found only in Siwani block of Bhiwani district (Fig.1) with about 50 percent of its area found to be degraded. Three blocks namely, Hisar-II (Hisar district), Kairu and Dadri-II (Bhiwani district) fall into the category of degradation intensity ranging between 18 to 27%. The highest place in extent of area dispersal was availed by partially stabilized dunes occupying 981.43 sq. km. in the study area. Tosham was the single block of Bhiwani district to fall in the category of 27-36 degradation intensity in terms of percentage.

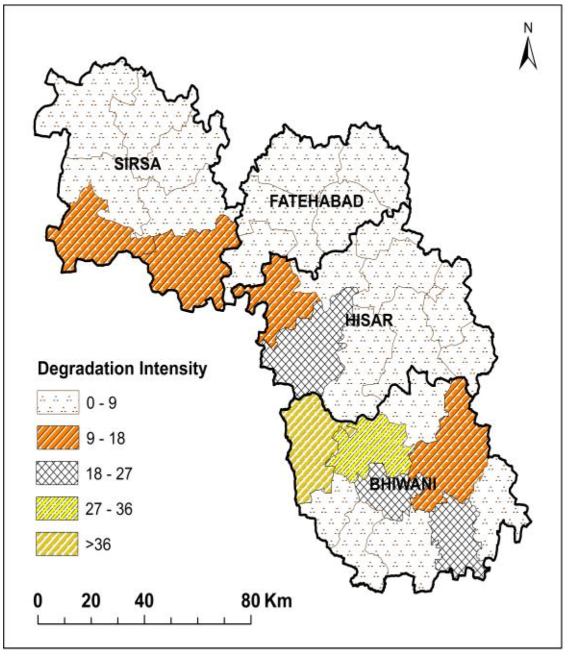

Fig.1. Degradation intensity in West Haryana

The blocks with higher intensity of degradation need a more planned strategy and strict policy formulation to overcome and manage the lands through proper orientation.

4. RECLAMATION AND DEVELOPMENT OF WASTELANDS

The economy of our country hinges on agriculture and its development. Because of heavy reliance on agriculture in India, the need of land use planning and agricultural resource development seems to be unavoidable fact. The limited available culturable land has to meet the demand of rapidly increasing population in the study region. Scientific improvements can revert back the potential of soil and make it productive over time. The methods has been reviewed and presented below for culturable lands.

4.1. Conservation Technologies for Soil Erosion:

Wind and water forms the premium source of erosion in soil removing the top fertile layer and its dispersal to other sites creating problem of sediment management. Soil erosion could be overcome by various practices of mulching, terracing, riprap, vegetation cover, matting and afforestation (Rivas 2006). The rehabilitation of these areas ecologically rests with silvipastoral systems (for fodder forage) and agro-forestry as a source of fuel and fruits(HARSAC, 1992). The trees should be characterised with rapid growth and high forage production and should be capable of withstanding looping, pruning and browsing. Since the main body of the sandy wastelands is stable, mulching of unstable parts like crests and flanks with indigenous plant species such as *Crotalaria burhia, Aerva tomentosa, Leptadenia pyrotechnica* and *Zizyphus nummularia* could be done to check the removal of sand from these parts.

The best remedy against erosion is definitely the vegetation cover cited by many authors in their work (Pimentel 2006; Troeh et al. 2004). A complete prevention of wind erosion can be achieved by covering 40% of prone area to erosion by vegetation. A 10% vegetal cover lowers the intensity of wind erosion however, below 10% coverage is not appreciated as control measure (Morgan and Finney 1987; Sterk 2000).

4.2. Reclamation and Management of Salt Affected Soils

4.2.1. Amelioration of saline soils: It refers to methods used to remove soluble salts from the root zone which render the relatively unproductive soil more productive. Commonly adopted methods are scrapping, flushing and leaching. The amount of salts removed depends entirely on the quantity of water that passes through the soil. The water quantity requirement for accomplishing leaching depends on the salt content (initial) of the soil, level of soil salinity desired, desired reclamation depth and characteristics of the soil in the area (Feng et al. 2005; Qadir et al. 2001 and Qureshi et al. 2008). Lowering of soil salinity by provision of sub-surface drainage depends on the amount of water applied and depth of drains. For effective leaching, proper levelling and bunding of the field, followed by shallow/deep ploughing to loosen the hardened surface, is necessary.

Saturated leaching (initial application of saline water followed by fresh water) is the best, as more salts are leached with equivalent amount of fresh water (Thokal et al. 1992). Salt leaching efficiency of saline sodic soils can be considerably enhanced by the application of amendments by preventing structural deterioration during leaching (Minhas and Sharma, 1989).

Drainage in areas of waterlogged, swampy or saline soils is one of the most indispensable measures for controlling soil salinization where natural outlet for drainage is not available. Mkrtchyan (1991) suggested open circulation of the drainage water, volume of irrigation water in relation to actual mineral content in ground and irrigation water of the irrigated lands.

4.2.2. Management Practices for saline soils: In situations where drainage is not feasible and sufficient water is not available for complete leaching, the soils can still be cropped with some loss in productivity by adopting special management practices (Li et al. 2008; Qadir and Schubert 2002 and Zhang et al. 2006).

4.2.2.1. <u>Selection of salt tolerant crops</u>: Crops grown on saline soils have different survival rate and yield potential. Tolerance of plant to salinity is not a fixed property of a species, but varies with the growth stage of a crop, varieties and climatic conditions (Scianna 2002).

Removal of exchangeable sodium and its replacement by calcium in the root zone is the basic improvement of alkali soils which is preceded by cropping on application of chemical soil amendments. Leaching is followed to removal salts formed as a result of amendment reactions.

4.2.2.2. <u>Chemical amendments</u>: Chemical amendments such as gypsum and calcium chloride directly supply soluble calcium for replacement of exchangeable sodium. Material like sulphuric acid, sulphur or pyrite makes the insoluble calcium into soluble form for replacement of sodium through biological and chemical reactions. Gypsum is by far the most common and economic soil amendments for alkali soils (Choudhary et al. 2008). Pressmud, a water product from sugar factories contains calcium sulphate some organic matter.

Patel and Singh (1991) studied the comparative efficiency of different amendments. Gypsum was most effective in reducing pH and ESP and increasing exchangeable calcium in soil than presumed and pyrite. Amendments like gypsum should normally broadcast and incorporated in the surface 10-12cm by dicing or using cultivator. Gypsum mixing in shallow depth is more beneficial than mixing with deeper depths.

4.2.2.3.<u>Organic manures as amendments</u>: The evolved carbon dioxide and organic acids on decomposition of organic manures lowers soil pH and releases cations by solubilizing calcium carbonate and other soil minerals which increases the electrical productivity, replaces sodium by calcium and lowers ESP. Gaffar et al (1992) reported lowering of SAR of sodium solution and improved permeability and physics conditions of sodic soil as a result of organic matter addition. Organic manures with inorganic amendments quicken the reclamation. Fatehkaran and Queshi (1988) reported efficacy of gypsum along with organic amendment like cow dung, FYM and *Cassia auriculata* (weed) for effective reclamation of sodic soils.

4.2.2.4. <u>Cropping</u>: The tolerance of crops to alkali conditions shows wide variation. Crop tolerance to alkalinity varies with the stage of growth, environmental condition and the varieties. Rice and Dhaincha shows higher tolerance, Wheat and Bajra are moderately tolerant, while leguminous crops are relatively sensitive to excess exchangeable sodium. Cultivation of rice in the initial stage of reclamation enhances reclamation considerably and results in reduced sodicity leading to continuous soil improvement.

4.3. Management of Alkali Soils

4.3.1. Nutrient management: Alkali soils are generally deficient in available nitrogen. High pH and poor soil physical condition aggravate at losses of the nitrogen and higher availability of phosphorous. Increasing sodicity also reduces the uptake of potassium. Long term N and P application lowers pH and improves the physical properties of sodic soils (Chawla and Chhabra 1991).

High pH, low organic matter content and presence of calcium carbonate reduces the availability of micronutrients and uptake of iron and manganese to plants grown in alkali soils. Soil submergence and addition of organic manure increase the extractable iron and manganese (Sharma and Yadav, 1988).

4.3.2. Irrigation: Alkali soils have low infiltration capacity, reduced available water capacity and poor ability to transmit water to growing roots. In general roots are confined to the layer improved after gypsum amendments. The number of irrigation to a crop need to be increased while reducing the depth of water applied at each irrigation. Sprinkler method of irrigation is promising.

4.3.3. Cultural practices: Cultural practices can often modify the adverse sodic condition, which may lead to optimum crop yields. Increased seed rate or number of transplants compensates the reduced germination and morality of seedings and improve crop stands. Planting trees on both sides of wide flat ridges as the best method of sugarbeet cultivation in sodic soils. Rain Water conservation by ridge trench system with Karnal grass lower the pH and EC on the side of ridge where wetting is frequent as compared to flat surface planting. Ridge trench planting caused submergence intermittent ponding and increased grass root activities. Improved spoil permeability displaces salts to subsurface layer and hasten the amelioration of sodic soil, supporting agro-forestry system (Grewal and Abrol, 1989).

4.3.3.4. Afforestation in Alkali Soils: For afforestation in alkali soil the breaking of compact subsoil layer or kankar pan is essential. Mixing of gypsum and organic manure in refilled pits improves rooting environment for tree establishment. Alkali tolerant tree species viz. *Prosopis juliflora, Acacia nilotica, Casuariana equisetifolia, Tamarix sp., Saivadora sp.* and *Terminalia arjuana* may be planted after initial reclamation. Similarly, *Suaeda fruticosa, Indigofera oblongifolia and Haloxylon sp*. are alkali tolerant shrubs which can be planted after initial reclamation.

Grasses are in general more tolerant to alkali condition than most field crops. Karnal grass (*Diplachna fusca*), Rhodes grass (*Chloris gayana*) and Para grass (*Brachiaria dactylon*) are highly tolerant to alkali condition and can be grown successfully in most alkali soils.

4.4. Solution to Waterlogging Problem

By surface of irrigation much more water is applied to crops than is necessary for them to grow. Continued use of water by this method has caused poor drainage problems at many places in many countries. Lining of farm irrigation channels, practice of deficit irrigation (i.e., irrigation much below the level of potential evapotranspiration), and water increase at least by 10% the efficiency of the surface method of irrigation ,are the other method to alleviate waterlogging and salinization problems.

Another solution to the problem of waterlogging is to introduce sprinkler system. It is particularly suitable for sandy areas where percolation losses from surface irrigation are high and where frequent light irrigation is preferred because of poor water holding capacity of the soil (HARSAC, 1992). The less we apply water to fields to optimize yields, lesser are the problems of waterlogging and salinity build up. Drip irrigation is the most common modern system of applying water directly to the crops root zone in an amount equal to the daily crop water requirement. The downward flow of water in deep soils is prevented by mutual action of evapotranspiration demand and a small amount of water applied by drip system.

Irrigation efficiency depends as much on the way in irrigation system is managed as on the type used. Farmers can also reduce their water demand and delay the process of waterlogging by restoring to deficit irrigation scheduling. Chatterji and Gupta (1969) and Tanwar (1984) recommended planting of salt tolerant species of trees belonging to the phreatophyte group on the sides of farm canals, field boundaries and roots which help to act as wind break, besides that have identified are *Acacia Senegal, Salvadora persica, Prosopis cineraria, Panicum turdigum, Crotalariab urhia, Acacia nilotica, Cauarina, Prosopis juliflora, Eucalyptus camaldulensis, Parkinsonia, Azadirachta indica, Dalbergia sissoo, Terminatis arjuna* and *Eucalyptus hybrid*.

5. ESTABLISHMENT OF HORIZONTAL LINKAGES FOR SUSTAINABLE DEVELOPMENT

Based upon the study of land use, geomorphology, soils, groundwater, rainfall, irrigation facilities available in the blocks, a series of packages of practices have been recommended for the overall sustainable development in the block on long term basis (HARSAC, 1999). For the farmers who can manage their lands intensively throughout the year, integration of recently developed alternate land use systems viz. agro-horticulture, agri-pasture, agro-forestry farm forestry, Silvi-pasture, etc, in suitable proportion, is advocated to attain the high yield plateau or unstained basis with the upgradation and conversation of various natural viz. land, water, vegetation and animal at their maximum level. Development of an advanced approach (validated model) for sustainable management of lands irrigated with saline/sodic waters could lead to reconsideration of previous assessments about suitability of some saline/sodic waters. The effective evaluation of quality of soil, crop production and quality of groundwater can be performed by use of a validation model. A task force acting between different sectors of natural resources and agriculture areas can be facilitated to define collaboration for establishing relations defining new ways of issue resolving. The land use planning and management should be working in collaboration at district level to maintain a uniformity and sustainability in resource consumption and generation. The strengthening capacities of communities and technical staff at catchment, sector and district level would help support the restoration and sustainable management of agricultural landscapes. The inclusion of private sector helps strengthen the policy implementation working in an integrated environment.

6. CONCLUSION

The west part of Haryana has a considerate percentage of degraded lands approximately 11 percent of the total geographical area. Majority of these lands are accountable to cultivation except the anthropogenic (mining and brick kilns) areas of degradation which form only 382 ha of the area. The reclamation of these areas requires heavy investment and planning prior to identification and mapping the affected areas. A proper channel and management strategy for different types of identified degraded lands are summed up to strengthen the knowledge of soil management. The practical interventions of designed approach in different degradation types could help reduce and reverse degradation. Establishment of horizontal linkages between local farmers, policies, private sector and collaboration of land use planning and management organizations have more potential to manage degradation through an adopted integrated approach.

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